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OIL SPILL HAZARDS IN THE MACKENZIE
RIVER AND DELTA AREA AND
ADEQUACY OF CLEAN-UP PROCEDURES

BY
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EVIDENCE PRESENTED ON BEHALF
OF C.O.P.E.

BERGER INQUIRY DELTA
PHASE, February 1976

MAILED 100
EXHIBIT NO. 471
FEB 14/76
Involvement
C.O.P.E.

The Freshwater Institute of the Fisheries Research Board of Canada initiated a study of the impact of gas and oil pipelines, highway construction and operation, on freshwater ecosystems of the Mackenzie and Porcupine River watersheds in 1971. This was carried out under the auspices of the Environmental-Social Programme, Northern Pipelines. The Headquarters was in Winnipeg with a field logistics base at Yellowknife and field camps originally located in Fort Simpson, Norman Wells, Arctic Red River, Inuvik and Old Crow (Y.T.). Budgetary restrictions necessitated the closing down of the Norman Wells and Arctic Red River camps in 1972. The remaining camps were operable until the end of the Programme in 1974.

My affiliation with the project began in 1971 at which time I was a Research Scientist in charge of the Inuvik field-camp. In 1973 the Old Crow field-camp became included in the Inuvik operation, and came under my jurisdiction. Until the end of the Project I was involved in carrying out the oil spill impact evaluation of our work, gathering baseline ecological data for the Delta and nearshore Beaufort Sea area, writing reports and papers on these and related subjects.

Scope of Study

The first activity was to conduct a general survey of the distribution and abundance of aquatic organisms in this vast and biologically poorly-known region. Attention was focussed upon benthic organisms because they are of fundamental importance with respect to food-chain



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inter-relationships and their utilization by indigenous fish species. Moreover, because of their relatively sedentary existence they are well-suited to act as biological indicators of technological disturbance to their habitats. Selected physical and chemical parameters that control the distribution, growth and abundance of these organisms also formed an integral part of the study.

Following the general survey, an experimental approach was adopted to study the specific effects of two major types of disturbance to aquatic habitats occasioned by pipeline development. These were the effects of increases in suspended sediment from erosion and the effects of oil in water.

Suspended sediment studies were carried out primarily in the Fort Simpson area, while oil-spill studies were primarily undertaken in the Inuvik region. Data obtained from the whole area were, however, used to support the experimental studies, with sampling stations located throughout the Mackenzie and Porcupine systems.

Objectives of Oil-Spill Studies

Briefly, the objectives of this portion of the work were to:

- 1) Study changes in the structure of benthic communities in selected lakes and rivers of the Mackenzie and Porcupine watersheds in response to the addition of a Northern crude oil (Norman Wells crude).

- 2) Study changes in water quality associated with the addition of Norman Wells crude oil to the selected aquatic ecosystems in the study area.
- 3) Study the fate of crude oil following experimental spills on Mackenzie Delta lakes.
- 4) Study the effect of Norman Wells crude oil on the colonization of riverbed substrates by benthic organisms.
- 5) Make recommendations concerning contingency plans for spills of oil and other hazardous substances.

Problems of Oil Pollution

I would like to make some points concerning oil spills. First of all, the term "oil spill". This is a generic term which covers all types of petro-chemical that may be spilled from refined gasolines and kerosenes through to crude oil. It is the latter type of spill that conjures up most people's images of a disaster: a great black or brown mess, contaminating miles of rocky coastline or sandy beaches and causing death to thousands of seabirds. The visual impact of such an event is enormous. It gives rise to much the same emotion as would be expressed when one first visits a forest fire site immediately after a fire has swept through it. A common response would be "My God, how will it ever recover?" And yet, we know from experience that forest-fire burn areas do, in fact, recover within varying lengths of time according to their latitude, and are in fact an inherent part of natural change in such ecosystems. Much the same occurs in the recovery of an area that has been contaminated

by an oil spill. There are many incidents of major oil spills that have occurred in more temperate latitudes, such as the "Torrey Canyon" incident off the coast of the U.K., the 'Arrow' in Chedabucto Bay, on the Eastern Seaboard of this country and the Santa Barbara oil spill off the west coast of the U.S.A. All of these disasters had their impact on the marine environment, but it was not an irreversible one. In all three cases, there has, in fact, been recovery of many of the affected segments of the biota. I do not wish to imply by these remarks that oil spills do not cause any damage, or that their effects may not be long-lasting, but I do hold out the candle of hope that there will be recovery. By "recovery" I do not necessarily mean a reversion to the former state before the oil spill. Ecosystems have a built-in resilience at any latitude, and providing certain limits are not exceeded, they will usually recover to restore a new balance of nature. Whether this new balance is acceptable to man or other components of the ecosystem, is not always readily assessable.

Another feature of the visual impact of an oil spill is that, it is the conspicuous or highly visible components of ecosystems such as seabirds, which are readily seen to be adversely affected by oil. Birds are vertebrates (animals with backbones) and vertebrates only make up 5% of the animal kingdom. The other 95% is composed of animals without backbones, which are generally much smaller occur in far denser populations and many of which are microscopic. It is such microscopic components of ecosystems, both animals and plants, which

form the basis of the food chains in the Beaufort Sea or the Delta aquatic ecosystems. Such components may be just as adversely affected by the presence of oil as seabirds, even though this is not very often readily apparent. The implications of such an effect in terms of the total integrity and stability of an ecosystem, are far reaching. This has special significance in terms of the Mackenzie Delta ecosystem because of the position this area occupies in Northern Canada. It is very different from most other areas of the world which are being subjected to oil spills. Most of the classic Maritime oil spill disasters have contaminated large areas, predominantly rocky coastlines. These coastlines are usually associated with a high degree of wave and surf action. Rocks that become contaminated with crude oil are thus usually subjected to strong tidal and wave action which would tend to cleanse them. They are also exposed to the natural cleansing activity brought about by indigenous organisms, such as snails and limpets. These animals scrape the oil from the rocks and thereby assist in the clean-up process in temperate latitudes, but they do not occur along the coastline of the Beaufort Sea.

To date there have been no major oil spill disasters that have contaminated large areas of relatively quiet water with extensive mud-flat zones. Such a situation clearly exists in the Mackenzie Delta and the nearshore Beaufort Sea area including the Tuk Peninsula. Here we have an area where there are deltaic processes going on, creating large areas of sedimentary habitats. These

sediments are composed of very fine particles, (silt) which are very readily admixed with oil. In addition to this, the self-cleaning ability of the area is severely restricted compared to a rocky shore, where the mean tidal amplitude is approximately 1 or 2 feet. Wave and surf action is also far less than that normally experienced on more temperate rocky shores. As a general rule of thumb the smaller the particle size of the sediment, the greater is its potential for contamination with oil. There are several documented cases where sandy beaches have been contaminated with oil from a spill, often to a depth of several feet. As I stated earlier, there has been no major oil spill in a tidal mud-flat area, which, by and large, supports a more abundant and diverse community, with which to compare effects. However, the potential for the adsorption and holding of oil following a spill is potentially far greater in such an area than it is in a sandy area, and obviously more so than for a rocky area. It would therefore seem that the Mackenzie Delta and its immediately adjacent off-shore area, represents a set of conditions which would tend to maximize the adverse effects of an oil spill were one to occur there. The present level of hydrocarbon exploration activity in that area certainly increases the probability of an oil spill event. The Delta is the focal point of gas and oil development activity in the western Arctic. The main concern which therefore

faces this productive area, is one of cumulative impact. Not only do we have the possibility of major crossings of Delta channels by the trunk gas-line itself, but there is also the additional consideration of the gas-processing plants, offshore drilling activity, and in the future, an oil transportation system, probably an oil pipeline. Each of these activities has associated with it the potential for spills of fuels of various kinds and crude oil itself. These range from the minor incidents involving only a few gallons or a few hundred gallons of diesel fuel or aviation fuel, up to the many thousands of barrels of crude oil which would occur in the event of an uncontrolled well-head blowout during offshore drilling or an oil pipeline rupture. The time of year at which any spill event occurred in the Delta is of prime importance in determining the magnitude of the impact. No time of the year would be a good time to have an oil or fuel-spill in the Delta! The time at which one could best be dealt with would be in the winter if the spill occurred at the surface of the ice, that is, on top of the ice. If it occurred under the ice, then not only would it be very difficult to map the course of the spilled material, but the recovery of fuel would also be difficult to achieve. The worst time would probably be just following spring breakup when the Mackenzie River is at peak discharge, most of the Delta is flooded, and there is still some ice about. Ice can have useful and impeding effects in terms of oil spill cleanup and

containment. In some cases, ice can act as a very efficient natural barrier and assist in ponding the oil, thereby facilitating its subsequent removal. If the ice is on the move, however, this would hamper the deployment of cleanup equipment and procedures. Following spring breakup, a spill of any kind of petro-chemical would be distributed rapidly by the channels of the Delta, which would act as arteries, allowing maximum dispersal within the shortest time. It would also affect most of the Delta lakes in its path which are normally flooded at that time. Later on in the season, many of these same lakes would be immune from contamination by oil in this way.

Effects of Oil

Having outlined the broad area of concern: the susceptibility of the Delta area to petro-chemical pollution, I would like to briefly summarize the salient features of the effects of crude oil and petroleum products.

Seabirds are probably the most obvious casualties of oil-spills. Mortality usually results from the destruction of the water-proofing and heat-insulation ability of their feathers and also from oil-ingestion during preening. The Delta and offshore areas are utilized extensively by many bird species and apart from the direct mortality from oil-spills, there is the additional long-term component which may result from the loss of nestlings, the nest-sites themselves being rendered useless for future generations, by oil-contamination, and the threat of degrading feeding, brood-rearing and staging areas.

Within the aquatic environment, the more mobile organisms, e.g., fish, can, and often do, avoid contamination by oil. This may not always be possible in shallow areas, in small lakes or in coastal embayments. The Delta has many examples of these three types of habitat, and of special significance here is the fact that the latter two habitats are known to be feeding and nursery areas for the juveniles and fry of several fish species. Fry, in particular, are especially susceptible to oil-contamination since they usually inhabit the upper water layers. The toxic, aromatic, lighter fractions of fresh crude oil can kill fish directly. Other longer-term effects include the formation of gill-lesions and certain forms of skin-cancer.

Beluga whales are annual visitors to the Delta area and an important resource for the local people. These mammals also have the potential to avoid oil-contamination, but these animals utilize the ice-leads extensively in early spring. Such leads would be natural 'ponding' areas for any oil pollutant. Although nothing is known of the effect of petroleum products on beluga, enzymology studies currently being carried out by Dr. J. Geraci at the University of Guelph indicate that their skin may be the major osmoregulatory organ of these animals and is obviously highly susceptible to any adverse effects resulting from contact with oil.

Aquatic invertebrates show a spectrum of sensitivity to oil pollution. Some species suffer massive mortalities, e.g., freshwater zooplanktonic crustaceans and marine amphipods (shrimp-like crustacea), whilst others are relatively tolerant. Zooplankton in Delta lakes and amphipods in the nearshore Beaufort Sea are very abundant and are extensively utilized as food by fish and marine mammals.

My own work concerning the effects of relatively small quantities of crude oil in Mackenzie Delta lakes indicated a subtle re-arrangement of benthic communities and produced an ecological shift. Certain organisms were completely wiped out, to be replaced by others which were relatively rare prior to the spill. After three years a new balance has been established, but the faunal assemblages are quite different to those occurring before the spill. We determined that the most toxic fractions of two types of crude oil disappeared very soon after the spill and that approximately half the oils had evaporated after two days, leaving the heavier tarry residues. From our research studies, we hypothesized three phases of oil-effects in a Delta lake. The first is characterized by acute toxicity and lasts a matter of days. This overlaps with, and is followed by, a period of physical entanglement or smothering lasting a few weeks. Finally, there may be a

prolonged chronic effect similar to eutrophication. This phenomenon is not usually welcomed by society, since it results in the proliferation of 'nuisance' algae and 'trash' fish at the expense of more desirable life-forms. Ecologically, the system has become impoverished. Diversity of the system has decreased and a natural balance has been destroyed. The implications of this could be far-reaching depending upon the size of the area affected. With respect to the Delta, I would like to point out that I consider the lakes (clear ones in particular) to be oases of productivity which support not only the aquatic communities which I have been studying, but are integral components of a much larger system encompassing locally important species such as muskrat and waterfowl, all of which interact to produce the typical Delta ecosystem as it exists today.

General Concerns

So far I have concentrated upon the Delta area, its susceptibility to petrochemical pollution and potential impact. This does not mean that spill problems may not occur or that they are of lesser importance elsewhere in the Mackenzie Valley. Until an oil pipeline down the Mackenzie Valley is proposed, I consider the main threat to aquatic systems above the Delta posed by pipeline petrochemicals to be fuel spills from on-land storage sites, or during transfer by pumps or trucks, and spills of pipeline test-fluid (methanol) either during the testing process or during transfer or storage.

Spills of even small to moderate quantities of fuel into any of the relatively productive, clear-flowing eastern-draining tributaries of the Mackenzie to be crossed by the gas pipeline, are likely to cause impoverishment of the downstream areas similar to that seen in our Caribou Bar Creek oil-spill experiment. In this experiment a small quantity of crude oil caused a reduction in benthic organisms of one-third their pre-spill abundance. Successive spillages or heavier contamination may produce an even greater decrease, thereby seriously affecting the suitability of that stream for fish utilization and impairing its overwintering capacity or destroying its spawning potential. Our experimental section of Caribou Bar Creek recovered almost completely one year following the spill, but it may not be safe to extrapolate this effect to any system, particularly where there is a greater potential for substrate contamination, either by virtue of different sediment composition or larger volumes of oil or fuel spilt. Streams in more temperate latitudes which have been subjected to fuel spills have not recovered over a period of four years.

The North has a history of fuel spills in the thousands of gallons category, most of which have been attributable to human error or equipment malfunction. I have read articles concerning the Delta Environmental Protection Unit contingency measures and equipment. I have never seen a comprehensive D.E.P.U. contingency plan for the Delta itself! Containment booms and slick-lickers appear to

be heavily relied upon in the CAGSL Application and the Delta as a whole. My main concern stems from the fact that to the best of my knowledge containment booms are not effective in currents equalling or exceeding 4 ft/sec. (2-3 kt) or with effective wave heights exceeding 3 ft. These conditions are equalled or exceeded throughout much of the Mackenzie system. Apart from the efficacy of such equipment I have concerns regarding the rate of execution of contingency measures and training of personnel. These concerns can best be framed in the following questions I would ask of the Applicant regarding his contingency plans.

1. What measures are being taken to ensure that transfers of fuel and other hazardous chemicals will take place with minimal risk of spillage?
2. Have the containment and cleanup measures envisaged by the Applicant been tested under the conditions in which they are anticipated to be used?
3. Does the Applicant intend to test such procedures and equipment periodically? If so, how frequently, and does he intend to have practice drills to ensure that personnel are familiar with, and proficient at, executing such procedures?
4. How does the Applicant intend to anchor a boom in the Mackenzie River and what is the response time to deploy such equipment?

I feel that any contingency plan should cover these points.

These comments and concerns are also applicable to the Gas Gathering Facilities but they assume more importance in this respect since storage and fuel utilization at a specific location will probably be greater than at similar sites along the trunk gas line. The size of the area potentially susceptible to spillage is also larger. This fact together with the low topographic relief at two of the gas-plant sites, coupled with their proximity to the Beaufort Sea also increase the potential ecological impact.

The gas-producers are contributors to D.E.P.U. and appear to be using that Unit as the main component of their contingency plans for spills in the Delta area. The misgivings I have concerning the efficacy of booms are also pertinent in this context. Because of the Northerly location of two of the gas-plants, the distance to coastal areas, where fuel-spill impact is likely to be greatest, is very short. Time for the deployment of containment and cleanup equipment will likewise be very short. In the area of Richards Island which I am now considering, the topographic relief is very low and any failure or delay in containing a fuel-spill will expose the slick to storm-surges. This would increase the probability of contaminating large areas of land and lakes as well as the coastal region, with its sensitive avifauna and fish-rearing habitat. An additional problem arises in this area, should a spill get out of control and contaminate the coastline and inland areas resulting from storm-surge activity, and this is one of on-land cleanup. Because of the susceptibility of this particular terrain to vehicular disturbance, no heavy

cleanup equipment could be used there and cleanup could only be effective using a large amount of manpower. I have not seen this problem addressed in any contingency plan.

Such concerns are relevant when considering fuel-spills originating at two of the gas-plant sites, but a new dimension is added when considering effects on the same area resulting from uncontained well-head blowouts during offshore drilling for oil. This is the substance of the Preliminary Environmental Assessment - Offshore Drilling for Oil in the Beaufort Sea, which is an exhibit at this inquiry. I do not propose therefore, to go into this issue in detail as I believe it will be dealt with more thoroughly by other Panels. I would, however, like to summarize the main points and add a concern of my own which is not really addressed in that document.

Firstly, by virtue of the possibility of large volumes of crude-oil being released over a long period of time, and also by virtue of the locations of proposed drill-sites, the possibility exists of far more extensive coastal and Delta contamination than would be the case with fuel-spills from either the gas-plant locations or trunk gas pipeline sites. Secondly, a spill from either of the proposed drill-sites has the potential to contaminate the first major lead which opens up annually offshore from the Delta. This is a very important zone with respect to migratory birds, beluga whales and seals, in the Spring. The potential for impact is great. The major concern

with respect to contingency planning is that we are largely in the realm of untried technology. Any of the conventional containment and cleanup devices currently used at offshore locations elsewhere have not been proven to operate under ice-infested conditions, such as those in the Southern Beaufort Sea. Some work carried out under the auspices of the Beaufort Sea Project indicate that under certain conditions oil in the ice-covered areas can be burned off. There is no doubt that fresh crude will burn, even in Arctic conditions, but weathered oil is another proposition. It should be pointed out that attempts to remove 'Torrey Canyon' oil at sea by burning were a failure, even with the application of gasoline and napalm. It is also impossible to ignite emulsified oil and this brings me to the concern not really addressed in the Beaufort Sea Assessment. A well-head blowout is accompanied by large volumes of gas. The possibility therefore exists that there may be extensive emulsification of released oil. This would pose two problems. Firstly it would disperse the oil over a wider area and secondly it would destroy the ability to remove such oil by burning - the most effective cleanup procedure currently available.

Clearly, there is a need for a speeding up of the Research and Development aspects of oil-spill containment in offshore areas. Devices which show promise for Arctic operations are surface 'curtains' to confine oil and gas from a blow-out to the drill-site and underwater domes for use on the sea-bed.

It is also clear that in the case of oil or fuel-spills, the old adage: "an ounce of prevention is worth a pound of cure" was never more true. The cost of cleanup following any of the major maritime oil-spill disasters was enormous. The cost of compensating the local Fishery alone, following the Mizushima oil spill in Japan, was \$56 million (personal communication, C.W. Nicol, Canadian Observer). This latter incident also has implications in the current discussion of Delta impact. The Mizushima spill of some 104 million gallons of hot bunker-C oil, occurred when a steel storage tank in a dyked enclosure ruptured. The dyke was breached and oil flowed towards a harbour. A contingency plan, which was hitherto regarded as being adequate, was immediately executed. This involved 30,000 metres of boom, 738 boats, 153 aircraft, a great deal of ancillary equipment and 8,189 workers. The spill could not be successfully contained, even by this massive operation. Furthermore, it occurred under nearly "ideal" conditions, i.e., manpower and equipment availability was no problem and the area was relatively calm compared to the Beaufort Sea and Delta area. There are obviously grave implications should a similar event occur in the Canadian Arctic.

The adequacy of dyking procedures is relevant to the discussion of this and similar problems. It should go without saying that a dyked area should be impermeable to the fluids it must contain, but I know of at least one fuel-storage dyke in the North which was constructed of porous material. The Applicant states that his dyked areas will be

'impermeable'. Details should be provided as to how the required degree of impermeability is to be achieved, the anticipated life-span of such dyked areas, inspection procedures and maintenance programmes.

Concerns regarding Pipeline-testing

It is my understanding that the Applicant intends to use methanol as a freeze-depressant in the testing of all pipeline sections north of 60. The Applicant states that test-sections will be 10 mile spreads filled by a 26% methanol solution. I believe that this test spread-size has now been reduced to 3 miles. The proposed method of disposal of the 1% solution does not pose a major threat to the integrity of aquatic ecosystems but this is not the case with the 26% test solution. The Applicant has no specific contingency plan to deal with the possibility of all the methanol contained in a test-spread (approximately 1 million gallons) being released during a test. Methanol solutions of only a few per cent have been shown by the Applicant to pose a threat to Arctic fish and their eggs. The greatest impact of a methanol spill during a test would occur if all the fluid entered a low-discharge, clear river (such as most of the eastern tributaries of the Mackenzie) which has flow under ice, during the winter.

I have estimated that if this were to occur say, in the Martin River at its lowest winter discharge (approximately 5 c.f.s.), the methanol would replace the normal water flow for 11 hours over a distance of two thirds of a mile. Assuming dilution to a 4% solution in the river, these two figures would be increased by a factor of six. A 4% solution will adversely affect fish eggs and probably also the benthic invertebrates. By contrast if the spill event occurred at the proposed East Channel crossing site, the impact would be negligible, owing to the relatively high discharge even during winter (26,500 c.f.s.). Corresponding figures for this crossing would be 7 seconds and 0.7 feet. The dilution effect is readily apparent.

Lakes present a different set of problems since their water is static, under winter ice, and dilution of introduced methanol would be a slow process. Assuming a small lake (similar to those close to the pipeline route) with a volume of 12 million gallons, the introduction of 26% methanol from a 3 mile spread would ultimately result in a 5% solution in the lake. This is cause for concern. Larger lakes affected in this way would be expected to have lesser impacts in relation to their larger volume.

I would like to emphasize that these estimates are based on assumptions and probably at best give the problem an order of magnitude. It would assist the assessment of impact if the

Applicant were to give detailed information concerning the test procedure itself particularly at water-bodies.

Recommendations

To alleviate the major concerns I've outlined, I would propose the following recommendations:

1. High priority should be given to the early detection of spill incidents and to the training of conscientious operators and supervisory personnel.
2. High priority should be given to dyked area design, construction and inspection.
3. Oil-spill containment and clean-up technology research and development should be accelerated.
4. Adequate environmental monitoring programmes should be set up to follow all aspects of pipeline construction, operation and maintenance. These would probably best be carried out by joint Industry/Federal agencies.
5. Federal regulatory and enforcement agencies should ensure that there are adequate personnel to deal with a development of the nature and magnitude as that proposed.
6. In the absence of an adequate contingency plan to deal with methanol spillage during pipeline testing, the applicant should reconsider the use of heated water as a test-fluid with its subsequent return to natural watercourses after treatment, cooling, and aeration.

WITNESS

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1. Environmental-Social programme studies on oil spill hazards in the Mackenzie River and Delta. Adequacy of Contingency planning to prevent spills.
2. Effects of siltation on aquatic ecosystems with particular reference to fish and fish food organisms.
3. Impacts of Toxic substances in water, i.e. testing fluids (Methanol), Aryl Phosphates etc. Contributor to PAAG report.
4. Adequacy of delta producers application to DINA.

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